Jan. 1, 1946. P. P. JOHNSON 2,392,152

METHOD OF COLD WORKING HOLLOW HEADED ARTICLES

Filed Jan. 24, 1942

Fig. 1.

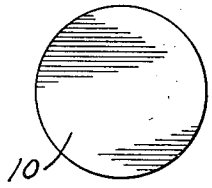


Fig. 2.

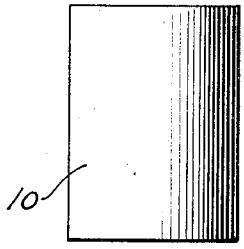


Fig. 3.

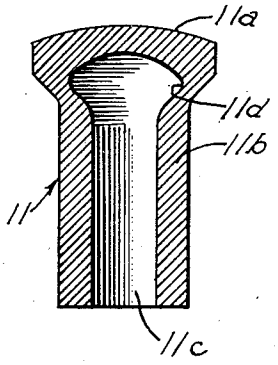


Fig. 4.

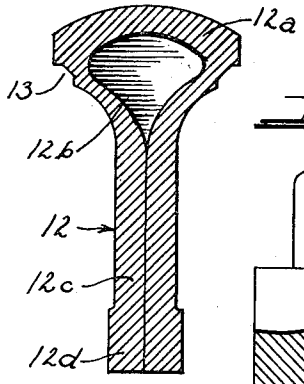


Fig. 5.

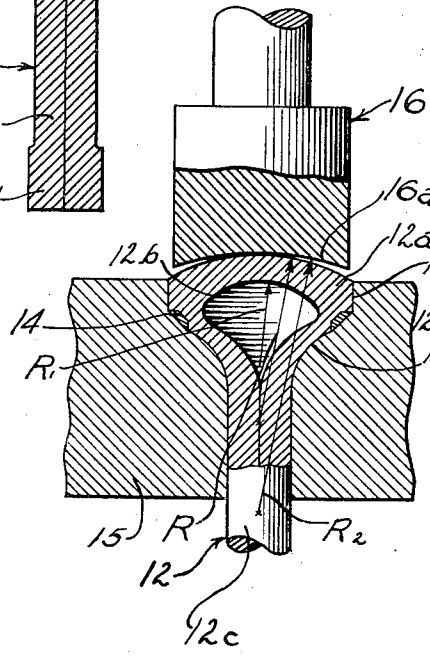
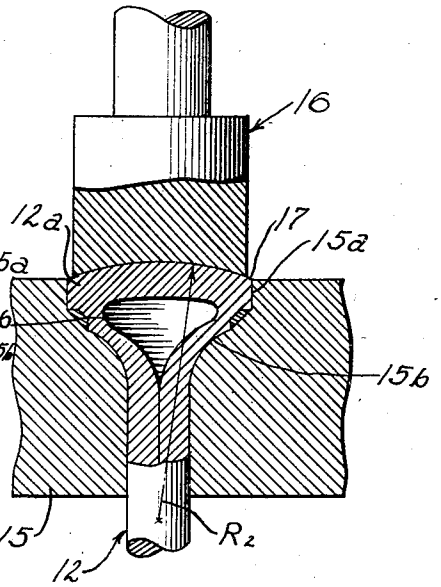


Fig. 6.



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METHOD OF COLD WORKING HOLLOW HEADED ARTICLES

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Application January 24, 1942, Serial No. 428,136

4 Claims. (Cl. 29—156.7)

This invention relates to the strengthening of the heads of hollow headed articles such as poppet valves.

More specifically the invention relates to the cold working of hollow arched or domed poppet valve heads to increase the hardness, strength and elastic limits thereof.

Increasingly heavy duty in aircraft engines has caused collapse of the domes of hollow head valves. To overcome this deficiency the valve heads have been made with thicker dome walls. However, the increase in thickness of a valve wall is objectionable because it increases the weight of the valve and decreases the cooling rate thereby causing the valve head to assume higher temperatures in operation. As the valve increases in temperature its tendency to warp and distort increases so that the solution of the collapsing problem by way of thicker dome walls for the valve is not satisfactory.

According to the present invention hollow arched or domed poppet valve heads are cold worked to increase their strength so as to enable them to resist collapsing forces even when they are subjected to the very severe operating conditions in high speed, high compression aircraft engines, without, however, increasing the weights of the valves.

According to this invention a hollow headed valve blank is formed with a domed or arched head which is preferably segmental spherical in shape and has the segmental spherical head surface generated with a shorter radius than that desired in the finished valve. In other words the dome may be a section of a true sphere of small radius whereas in the final valve the section has a longer radius to provide a more flattened dome. The valve blank with the domed head is seated in a close-fitting die which supports the head around the entire periphery thereof. A punch having a concave segmental spherical pressing surface with a longer radius than that of the dome of the blank is then forced against the dome so as to deform it. The partial collapse of the dome into conformity with the curvature of the pressing surface cold works the valve metal. Since the die will not permit spreading of the head all of the stresses in the head will be around the dome and, as a result, the hollow cavity in the valve is not destroyed. If desired the diameter of the punch can be slightly less than the diameter of the valve head to provide an exposed marginal area around the dome of the valve wherein the valve metal can flow. This permits the flashing of the metal around the punch and prevents excessive die stresses.

Since the valve blanks are usually made of austenitic steel the cold working operation can be carried out below the recrystallization temperature of the steel thereby causing a permanent deformation of the components of the aggregates in the steel which may be composed of cementite and austenite. This permanent deformation is effected by distorting the existing structure in the steel chiefly through the stretching or elongation of the crystalline elements in the direction of the applied stresses. Actually, the distortion or straining of the metal does not result in a distortion of the crystals but rather involves a yielding of the crystals through successive crystalline slip planes. The cold worked metal has an increased tensile strength, elastic limit, and hardness.

If the valve head is to be provided with a hard seat such as a Stellite seat, the Stellite material can be puddled or welded into a groove in the blank before the cold working operation so that, after the cold working operation, the blank need not again be heated to forging temperatures which might destroy the cold worked properties of the valve head.

It is, then, an object of the invention to increase the strength of hollow headed articles without increasing the weight of the articles or the thickness of the article walls.

A further object of the invention is to provide a process of cold working the domed or arched heads of hollow headed articles to improve the metallurgical characteristics of the articles.

A still further object of the invention is to partially collapse arched or domed heads of hollow articles to improve the characteristics of the heads.

A still further object of the invention is to cold work the heads of hollow headed poppet valves through a partial collapse of the head arches or domes.

Another object of the invention is to reshape the arches of hollow headed poppet valves through a pressure deformation treatment and thereby cold work the heads.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheet of drawing which by way of a preferred example illustrates one embodiment of the invention.

On the drawing:

Figure 1 is a plan view of a metal billet from

which a valve according to this invention may be formed.

Figure 2 is an elevational view of the billet.

Figure 3 is a vertical cross section of a blank formed from the billet of Figures 1 and 2 during the process of preparing a hollow valve from the billet.

Figure 4 is a vertical cross-sectional view of a valve blank formed from the blank of Figure 3.

Figure 5 is a vertical cross-sectional view, with parts in elevation, illustrating the manner in which the blank of Figure 4 is subjected to the cold working operation according to this invention.

Figure 6 is a view similar to Figure 5 but illustrating the form of the valve blank upon completion of the cold working treatment.

As shown on the drawing:

In Figures 1 and 2 the reference numeral 10 designates a solid cylindrical metal billet or slug preferably composed of a steel suitable for a poppet valve such as, for example, an austenitic steel.

A nickel-chromium alloy austenitic steel resistant to corrosion is highly desirable. A steel of this type having very desirable properties for hollow valves is one having the following formula:

	Per cent
Ni	14
Cr	14
W	2.5
C	0.35
Fe	Remainder

The billet 10 is heated to a forging temperature and die pressed over a central stake to form the thimble-shaped blank 11 of Figure 3. The thimble-shaped blank has a domed or arched head 11*a* and a hollow shank or body portion 11*b*. The blank 11 from the die pressing operation is reamed out to provide a cylindrical cavity 11*c* closed by the head 11*a* and having an enlarged inner end 11*d* which can be formed by an undercutting tool.

The blank 11 is then further forged by means of peening hammers to neck down the shank portion 11*b* adjacent the head 11*a* as more fully described in the McBride et al. Patent 1,984,751, dated December 18, 1934. After the shank has been necked down the blank is further die pressed through an extruding die as also described in the referred to McBride et al. patent to produce the valve blank 12 of Figure 4. This valve blank 12 has a domed or arched hollow head 12*a*, a hollow head cavity 12*b* and a collapsed solid valve stem 12*c* with a nubbin end 12*d*. The neck of the valve between the head 12*a* and stem 12*c* can be machined to provide a groove 13 for receiving a seating ring 14 (Figures 5 and 6) therein. The seating ring can be composed of a hard alloy such as Stellite and can be puddled into the groove 13.

The blank 12*c* with the seat 14 therein is next mounted in a split die 15 as shown in Figures 5 and 6. The die 15 snugly receives the neck of the valve, at least a portion of the valve stem 12*c* and confines the entire periphery of the head 12*a*. In other words the die 15 is formed with a shoulder 15*a* snugly seating the side wall of the head 12*a* and a converging seat 15*b* snugly receiving the neck of the valve.

As best shown in Figure 5, the outer top surface of the head 12*a* of the blank 12 is a segment of a sphere having a relatively short radius R centered in the axial center of the stem 12*c* just adjacent the neck portion of the blank. The head 12*a* is thus domed or arched to a considerable extent, which is more than that desired in the finished valve.

The cavity 12*b* of the blank has the head wall surface thereof struck from an even shorter radius R_1 centered in the cavity as shown in Figure 5. As a result, the dome-defining wall of the head 12*a* is somewhat thinner at the axial center thereof than at the outer ends thereof. The shape of the dome-defining wall is controlled by the shape of the dies and reaming tools used in forming the blank.

When the blank 12 is at a temperature below the recrystallization range of the steel from which it is made, a punch 16 having a concave pressing face 16*a* is brought down on top of the valve head 12*a*. The face 16*a* of the punch 16 has a segmental spherical depression struck from a radius R_2 which is longer than the radii R and R_1 of the valve dome wall. As a result, the pressing face is flatter than the dome wall and will effect a partial collapsing of the wall as shown in Figure 6. Since the die 15 confines the valve head 12*a* against spreading, the dome or arch of the valve head will be flattened without destroying the cavity 12*b*. During the pressure treatment the valve head 12*a* is therefore deformed and cold worked since the punch will flatten out the arched or domed wall of the valve head and, in so doing, will cause a yielding of the crystalline elements in the steel of the head through successive crystalline slip planes thereby giving the head cold worked metallurgical properties. The deformation of the head effected by the punch will somewhat thicken the dome wall at the center thereof as indicated in Figure 6 so that it has substantially uniform thickness across its span. All of the forces during the pressure treatment are around a sphere and spherical distance from side wall to side wall of the valve head has decreased with a resulting increase in thickness of the head. The increase in thickness is greatest at the center.

The punch 16 is preferably of smaller diameter than the diameter of the head 12*c* so as to expose a marginal area 17 of the valve head as shown in Figure 6. This will permit the formation of a small flash of metal which can bulge up around the punch. The formation of such a flash reduces stresses in the die 15.

The valve 12 can then be readily removed from the die 15, the stem 12*c* thereof drilled to provide a cavity therethrough communicating with the head cavity 12*b*, the resulting stem and head cavities partially filled with a coolant such as metallic sodium, and the nubbin 12*d* collapsed and plugged all as described in the McBride et al. Patent 1,984,751 to produce a finished hollow valve.

The valve, after cold working the head, can, if desired, be given a low temperature draw at 300 to 500° F. to restore its elastic limit. Such a treatment will not destroy the benefits of the cold working. As a result, the cold worked metallurgical properties of the head are maintained and the valve will have a much stronger head. The punch 16 is made with a larger spherical radius R_2 than that of the head of the valve blank, but this radius R_2 corresponds to the radius desired for the dome of the finished valve. Thus considerable cold working of the valve head is accomplished without collapse of the head cavity since all forces during the cold working treatment are compressive around a sphere. The

valve head, during the pressure treatment, is confined so that it cannot spread. The confining die forms a sufficient seat for the valve blank so that the blank will not be extruded during the pressure treatment.

It will, of course, be understood that various details of the method may be varied through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. A method of strengthening the heads of hollow headed austenitic steel poppet valves which comprises forming the poppet valve with a domed hollow head having a segmental spherical dome of shorter radius than desired in the finished valve, confining the internally unsupported domed hollow head against lateral spreading, maintaining the steel of the valve below its recrystallization range, and pressing against the dome of the confined head a spherically concave surface of longer radius than the radius of the dome of the head to partially collapse the dome into the desired contour while simultaneously thickening the metal defining the dome.

2. In the method of strengthening the domed heads of hollow headed poppet valves the steps which comprise confining against radial spreading the neck portion and hollow head of a valve blank having an internally unsupported head dome of shorter radius than desired in the finished valve, pressing a spherically concave surface against the dome of the hollow head of the confined valve to partially flatten said dome, and exposing a marginal area of the valve head during said pressing treatment to permit the formation of a metal flash around the valve head.

3. A method of strengthening the heads of hollow headed austenitic steel poppet valves, which includes the steps of forming the poppet valve with a hollow head having an external curvate surface of shorter radius than desired in the finished valve, confining the internally unsupported hollow head against lateral spreading, maintaining the steel of the valve below its recrystallization range, and pressing against the curved surface of the head another curvate surface of greater radius to reform the valve head into the desired contour while simultaneously thickening the metal in the upper portion of the hollow head.

4. In the method of strengthening the heads of hollow headed poppet valves, the steps of confining against radial expansion the neck portion and hollow head of a valve blank having an internally unsupported head having a generally arched top of shorter radius than desired in the finished valve, pressing another surface having a shape complemental to the desired shape of the finished valve against the hollow head to reshape the same, and exposing a marginal area of the valve head during said pressing treatment to permit the formation of a metal flash around the valve head.

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